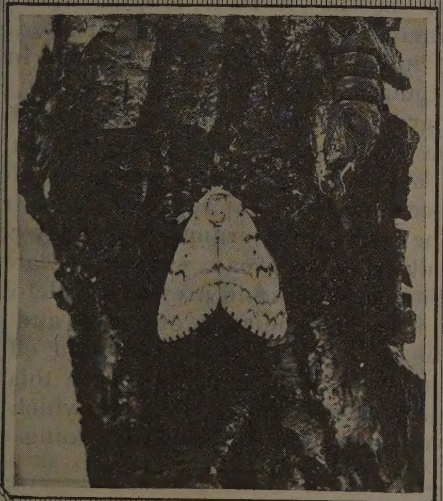
Superseded by Farm. Bull. 1623, 1930
E&A
Circ. 464, 1938
23 OCT. 1923

U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1335

CONTROLLING *the* GIPSY MOTH *and the* BROWN-TAIL MOTH



UNITED STATES DEPARTMENT OF AGRICULTURE
1862 1889

THE gipsy moth and the brown-tail moth are two very destructive enemies of tree foliage that were accidentally introduced into this country from Europe. Both have spread over a large part of New England, the gipsy moth now occupying about one-half and the brown-tail moth about one-third of that region. The gipsy moth has been found in one large area in New Jersey, but has been effectively controlled. Scattered colonies of this insect found in adjoining States from time to time have nearly all been exterminated. The area infested by the gipsy moth has increased, but the brown-tail moth at present occupies a smaller area than in 1914.

The Federal Government and the States concerned are cooperating in an unremitting warfare against these two insects. A Federal quarantine prevents the shipment out of the infested territory of products liable to infestation, except after strict inspection, under regulations made by the Federal Horticultural Board. The States and the Federal Government, the latter acting through the Bureau of Entomology, are both actively engaged in destroying these insects by the use of appropriate control measures. The Federal Government is chiefly concerned in preventing their spread, while the States aim to reduce their numbers and prevent the defoliation of valuable trees in woodlands, orchards, and parks.

The means which have been found effective in destroying the insects are set forth in this bulletin, followed by an account of the work which the Federal Government and the States are doing.

Washington, D. C. July, 1923

CONTROLLING THE GIPSY MOTH AND THE BROWN-TAIL MOTH.[1]

A. F. BURGESS,

Entomologist in Charge of Gipsy Moth and Brown-Tail Moth Investigations, Bureau of Entomology.

CONTENTS.

	Page.
Introduction and spread	1
The gipsy moth	6
Life history	6
Means by which the gipsy moth is spread	7
Food plants	8
Injury caused by the gipsy moth	8
Effect of climatic conditions on the gipsy moth	10
Native enemies	10
Introduced parasites and enemies	11
The brown-tail moth	11
Life history	11
Food plants	13
Injury caused by the brown-tail moth	13
Native enemies	14
Introduced parasites and enemies	14
Methods of controlling the gipsy moth	15
General methods	15
Methods to be used in orchards	20
Methods advisable in cities and towns	21
Controlling the gipsy moth in woodland	21
Methods of controlling the brown-tail moth	23
Controlling the brown-tail moth in woodland	24
Organization and status of work against the gipsy moth and the brown-tail moth	25
State work	25
Work of the Bureau of Entomology	26
Cooperative work	27

INTRODUCTION AND SPREAD.

IN 1869 a number of egg clusters of the gipsy moth,[2] a very destructive insect pest in Europe, were brought from France to Medford, Mass., by an astronomer who had the fanciful idea that he could cross these insects with silkworms. Later in the season some of the caterpillars escaped, and although none was found in the vicinity during the next few years, enough specimens survived to enable the species to establish itself. In the summer of 1889 this insect became so abundant that fruit and shade trees in the neighborhood were completely defoliated, and the caterpillars swarmed over the trees and into the houses and became a serious nuisance. This resulted in the loss of valuable trees and in the depreciation of property values in that section.

[1] This bulletin is a revision of and supersedes Farmers' Bulletin 845, The Gipsy Moth and the Brown-tail Moth and Their Control.

[2] *Porthetria dispar* L.

For about 10 years effective work against the gipsy moth was carried on by the State of Massachusetts, and during this period the insect was kept under control. The work was discontinued in 1900, but by 1905 the species had become so abundant and had caused such widespread injury that systematic work was renewed by the State in order to protect the tree growth in the infested area. This work has been continued up to the present time. As the insect spread to other New England States it became necessary to institute more extensive control measures.

In 1906, after the gipsy moth had become established in New Hampshire and Rhode Island, as well as in Massachusetts, an appropriation was made by Congress for suppressing it, and the Secretary of Agriculture was authorized to take all possible measures to prevent its spread. Since that time work has been carried on each year. The area in New England now known to be infested is shown on the accompanying map (Fig. 1).

In 1912 a small area was found heavily infested with the gipsy moth at Geneva, N. Y. Prompt action was taken by the State department of agriculture, and the Bureau of Entomology of the United States Department of Agriculture cooperated. The area was thoroughly scouted as well as a large belt of contiguous territory. Several very thorough examinations have been made since then, but no trace of the insect has been discovered.

In February, 1914, a small colony was discovered at Bratenahl, near Cleveland, Ohio. Immediate attention was given to this colony in cooperation with the Ohio Department of Agriculture. Very thorough inspection and treatment work was required for three seasons before the colony was exterminated.

In May, 1914, a colony was found by State inspectors in North Castle, Westchester County, N. Y. The infestation was heavy at the center, and scouting determined that it extended over about 1 square mile. Intensive work was done throughout this area and the surroundings, and although the locality was a very difficult one to treat thoroughly the area was cleared of the moth.

In July, 1914, a small colony was found at Rutherford, N. J., but this was exterminated.

August 20, 1912, Congress passed a law creating the Federal Horticultural Board, which was authorized to make regulations relative to the importation of plants and plant products from foreign countries and to administer foreign and domestic quarantines as a protection from injurious insect pests and plant diseases. This board requires the inspection and certification of all living plants before importation to this country, and by a system of permits and notification respecting the movement of such stock it is possible for the State inspectors to inspect it at destination.

Early in July, 1920, the gipsy moth was found on a large estate near Somerville, N. J., by one of the State inspectors. The infestation centered in a large plantation of blue spruce trees, several acres of which were defoliated. Some dead trees in the worst infested portion indicated that they had been killed as a result of defoliation and that the infestation was one of long standing.

Inquiry showed that these trees had been imported from Holland 10 years before, and there is no doubt that the infestation came with the shipment, which was received before the passage of the law creat-

ing the Federal Horticultural Board. This shows clearly the pressing need for precautionary measures to keep out dangerous pests.

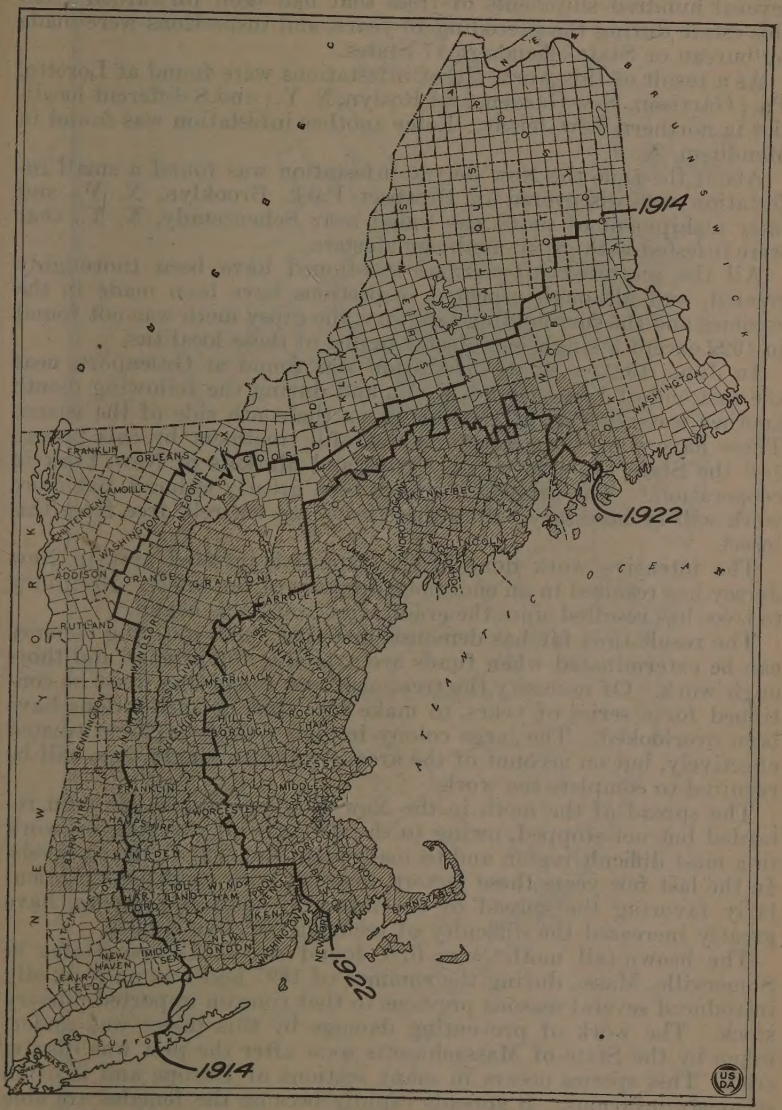


FIG. 1.—Map of New England. The shaded area is infested by and quarantined for the gipsy moth; the area between the line marked 1914 and the ocean and that between the line marked 1922 and the ocean were infested with and quarantined for the brown-tail moth in those years.

Scouting work carried on during the winter and spring was financed by the State of New Jersey and by the Federal Government,

and the insect was found at scattered points in an area of over 400 square miles. (Fig. 2.) In addition to this, it was necessary to trace several hundred shipments of trees that had been forwarded from this estate during the preceding 10 years, and inspections were made by bureau or State officials in 17 States.

As a result of this work, slight infestations were found at Loretto, Pa.; Garrison, Kew Garden, and Roslyn, N. Y.; and 8 different localities in northern New Jersey. Later another infestation was found in Mendham, N. J.

About the time the New Jersey infestation was found a small infestation was discovered in Prospect Park, Brooklyn, N. Y., and later a shipment of posts was found near Schenectady, N. Y., that were infested with gipsy-moth egg clusters.

All the scattered infestations mentioned have been thoroughly treated, and although repeated inspections have been made in the colonies and the surrounding territory, the gipsy moth was not found in 1922 except a single egg cluster in one of these localities.

In June, 1921, a small infestation was found at Greenport, near the east end of Long Island, N. Y., and during the following month another was reported at Patchogue, on the south side of the island. These have since been given very careful treatment by this bureau and the State Department of Farms and Markets of New York in cooperation.[3] The infestations have been greatly reduced, but more work will be necessary before these areas are entirely free from this insect.

The intensive work done in the extensive infested area in New Jersey has resulted in an enormous decrease of the insect. No injury to trees has resulted since the eradication work was begun.

The result thus far has demonstrated that small outlying colonies can be exterminated when funds are available for prompt and thorough work. Of necessity the treatment and rescouting must be continued for a series of years, to make sure that no infestations have been overlooked. The large colony in New Jersey has been treated effectively, but on account of the area involved a longer time will be required to complete the work.

The spread of the moth in the New England States has been retarded but not stopped, owing to the necessity of carrying on work in a most difficult region and to inadequate funds at critical periods. In the last few years these factors, together with conditions particularly favoring the spread of the insect by natural agencies, have greatly increased the difficulty of securing effective results.

The brown-tail moth[4] was first found in the United States in Somerville, Mass., during the summer of 1897 and was undoubtedly introduced several seasons previous to that time on imported nursery stock. The work of preventing damage by this insect was undertaken by the State of Massachusetts soon after the pest was discovered. This species occurs in many sections of Europe and is often seriously injurious. It spreads rapidly because the females are able to fly long distances. Suppressive measures by the New England States and by the Federal Government have been directed against this insect as well as against the gipsy moth.

[3] In March, 1923, the gipsy-moth work was transferred to the Department of Conservation.

[4] *Euproctis chrysorrhoea* L.

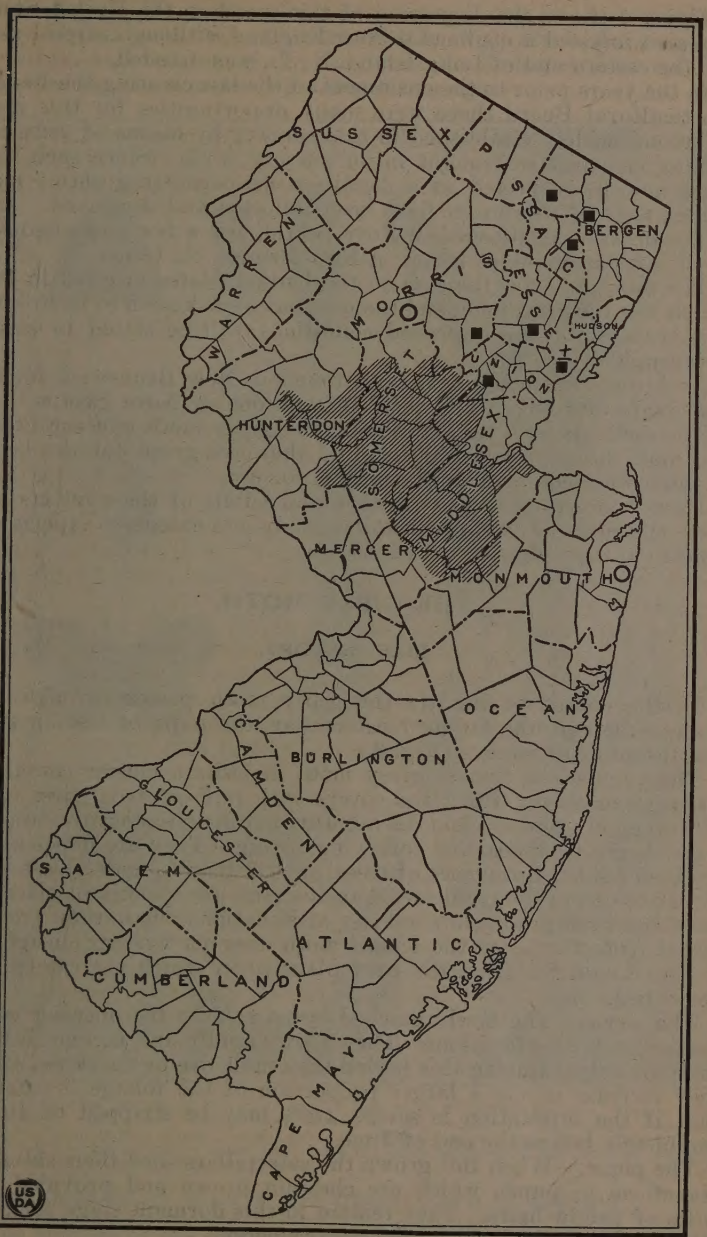


FIG. 2.—Map of New Jersey north of Camden. The shaded area is infested with the gipsy moth; the black squares are areas that were infested and have been cleared of the moth; the circles are areas that are still slightly infested.

Figure 1 shows the dispersion of this insect in the United States. The area infested is confined to New England, although several years ago the eastern end of Long Island, N. Y., was infested.

In the years prior to the enactment of the law creating the Federal Horticultural Board there were many opportunities for this insect to become widely established in this country by means of webs containing caterpillars brought in on nursery stock. Since such stock must now be inspected as a condition of permitting entry, many winter webs of this insect have been collected and destroyed.

The insect is established in Nova Scotia, and a few years ago scattered infestations were found in New Brunswick, Canada.

The map indicates the area in the United States infested in 1914, which was the maximum, and the territory now known to be infested. The reasons for the improved conditions will be stated in a later paragraph.

No brown-tail moths have been found in New Brunswick for several years and only small local infestations in Nova Scotia.

The methods used in suppressing the gipsy moth and the brown-tail moth have proved efficient, and they are given for the benefit of those who require this information for use.

Facts concerning the life history and habits of these insects have been obtained as a result of detailed study and extensive experiments conducted through a period of years.

THE GIPSY MOTH.

LIFE HISTORY.

In the course of its life the gipsy moth passes through four stages—the egg, the larva or caterpillar, the pupa or resting stage, and the adult or moth. (Fig. 3.)

The eggs.—The female gipsy moth deposits a cluster containing 400 eggs or more, which she covers with buff-colored hairs. Most of the egg clusters are laid during July and hatch about the time the leaves begin to appear the following spring. They are deposited on the under side of branches of trees, on tree trunks, under loose bark, or in cavities in the trunks or branches, and are sometimes placed on stones or rubbish and in a variety of situations where they are concealed from view. As the female moth does not fly, egg clusters are seldom found far from the food plant upon which the caterpillars developed.

The larvæ.—The newly hatched larvæ feed on the opening leaves, making small perforations. They grow rapidly and become full fed early in July. During this period they molt five or six times, and as they increase in size a larger proportion of the foliage is eaten, so that if the infestation is severe, trees may be stripped of foliage completely before the end of June.

The pupæ.—When full grown the caterpillars shed their skins and transform to pupæ, which are chestnut brown and provided with tufts of yellow hairs. They remain in this dormant stage for about 10 days, after which the adult insects emerge.

The adults.—The male moth is dark brown, with black wing markings, and flies well. The female is white, with black markings on the wings, and because of the weight of the abdomen does not fly. After mating, the females begin depositing eggs.

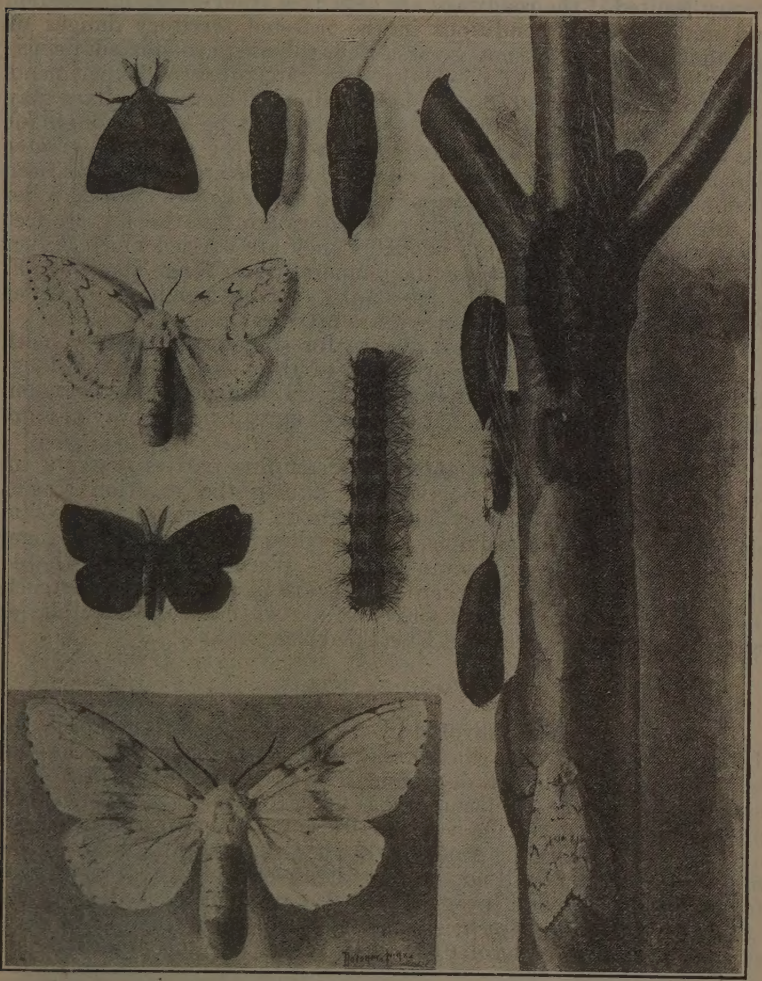


FIG. 3.—Different stages of the gipsy moth: Egg mass on center of twig; female moth ovipositing just below; female moth below, at left, enlarged; male moth, somewhat reduced, immediately above; female moth immediately above, somewhat reduced; male moth with wings folded in upper left; male chrysalis at right of this; female chrysalis again at right; larva at center.

MEANS BY WHICH THE GIPSY MOTH IS SPREAD.

Egg clusters of the gipsy moth, deposited on trees, lumber, stone, or other products that are likely to be shipped, may be carried long distances and cause the establishment of new colonies of the insect.

Spread in this way is prevented by inspection of such products before they are shipped. Caterpillars of this insect may be spread for limited distances by carriage on moving objects, such as trains, horse-drawn vehicles, or automobiles. The danger of such spread is very limited if the roadways are kept free from severe infestation, and under present conditions in the infested territory danger of spread in this way is not great. New colonies are started principally by the spread of newly hatched caterpillars. Experiments have shown that under favorable conditions these caterpillars may be blown by the wind. The temperature must be high enough for the caterpillars to be active and the stronger the wind the greater the probability of their being carried long distances. It has been demonstrated that caterpillars have been carried more than 20 miles in this way, and specimens have been caught in the air 50 feet above the ground, although probably they are carried much higher than this. It is necessary for the temperature to range above 65° F. and for the wind velocity to be 8 miles or more per hour, in order that wind spread of small caterpillars may result.

In the last few years a new avenue for spread of the gipsy moth has developed from the extensive use of the motor truck for long-distance hauling. Fortunately the material hauled is only occasionally of a dangerous nature, but chance of spread in this way is more or less constant.

The recent popularity of automobile camping parties presents another source of danger, particularly during the vacation season. There is a growing tendency, however, to restrict such camps to municipal or semipublic grounds. Under these conditions the danger can be minimized by proper inspection. Warning posters (Fig. 4) are being used in sections where parties are likely to camp, instructing them to examine their effects carefully so that no caterpillars or egg clusters of the insect will be carried away.

FOOD PLANTS.

The food plants most favored by the gipsy moth are the apple, the different species of oak, gray birch, alder, and willow. In cases of bad infestation nearly all deciduous trees are injured to a greater or less extent, with the exception of ash. Hickory is not a favored food plant, although the foliage occasionally shows severe feeding. Chestnut will not support the gipsy moth when the caterpillars are in the first stage, and pine will not support the first two stages; but if other food plants are present severe injury may result from feeding by the larger caterpillars. Beech is sometimes fed upon freely, and occasionally the trees are defoliated. This is true also of poplar.

INJURY CAUSED BY THE GIPSY MOTH.

Unless reduced in numbers by natural enemies, or by the application of control measures, the gipsy moth is capable of causing enormous injury to tree growth. In the area in New England which has suffered most from this insect thousands of trees are dead as a result of defoliation. (See Fig. 5.) Many areas were cut before the trees were mature and the wood sold at a loss on account of

damage caused by this insect. Apple and oak have been injured most, but pine and other coniferous trees mixed with deciduous growth have suffered severely.

It is undoubtedly true that many oak trees which have been weakened severely as a result of defoliation by the gipsy moth

AUTOMOBILISTS
AND
CAMPERS
CAREFULLY EXAMINE YOUR LUGGAGE OR CAMP OUTFIT, AND BE SURE NOT TO CARRY GIPSY MOTH EGGS OR CATERPILLARS.
This insect has caused the loss of MILLIONS OF DOLLARS to Fruit, Shade, and Forest Trees in New England.
Protect your property and assist the Government and State Authorities to control this pest.
Transportation of the Gipsy Moth is prohibited by Federal and State laws. Violation is punishable by heavy penalties.
U. S. BUREAU OF ENTOMOLOGY
MELROSE HIGHLANDS, MASS.
IN CO-OPERATION WITH
STATE ENTOMOLOGIST, DURHAM, N. H.
MAINE
VERMONT
NEW HAMPSHIRE
MASSACHUSETTS
R.I.
CONNECTICUT
MOTH LAYING EGGS
EGG MASS
PUPA OR CHRYSALIS
CATERPILLARS
THE GIPSY MOTH
U.S.D.A.

FIG. 4.—Warning poster.

and the brown-tail moth have failed to recover because of the attacks of certain wood-boring insects. The species which has caused most damage in this way is a beetle [5] known as the two-lined chestnut borer, the larva of which feeds beneath the bark of injured trees.

[5] *Agrilus bilineatus* Weber.

EFFECT OF CLIMATIC CONDITIONS ON THE GIPSY MOTH.

Recent investigations have shown that extremely low temperature during the winter is fatal to the eggs of this insect that have been deposited in exposed situations. From —20° F. to —25° F. is usually required to injure them sufficiently to prevent hatching, and if the clusters are protected by snow, ice, or other material, no injury to them results, even at this temperature. After extremely cold winters many eggs fail to hatch from this cause.

During May when the caterpillars are hatching there are sometimes long periods of cold weather accompanied by heavy rains. This condition, or the occurrence of severe frosts in June, occasionally causes the death of the least hardy caterpillars.

FIG. 5.—Woodland showing dead and defoliated trees due to gipsy-moth attack.

NATIVE ENEMIES.

Few insect enemies of the gipsy moth native to New England cause any noticeable reduction in its numbers. This is shown by the fact that between 1900 and 1905, when no systematic effort was made to suppress the insect, alarming injury resulted, and native insect enemies did not increase to any marked degree. The same is true of the work of native insectivorous birds. While they undoubtedly feed to some extent on gipsy-moth caterpillars, there is no case on record where they have been able to control the species. The "wilt," a disease that attacks and kills the caterpillars and pupæ, has probably occurred in this country for many years. During some seasons, particularly in badly infested areas, it causes the death of an enormous number of the caterpillars and is often an important factor in reducing the infestation locally.

INTRODUCED PARASITES AND ENEMIES.

In 1905 an effort was made by the State of Massachusetts, in cooperation with the Bureau of Entomology, United States Department of Agriculture, to introduce the parasites and natural enemies of the gipsy moth from its native home in Europe and Japan. Since that time a large amount of parasitized material has been received nearly every year, and as a result some promising natural enemies have become established in this country and are assisting in bringing about the control of the species. The enemies which have become established and are at present destroying the largest number of gipsy-moth caterpillars and pupæ are the Calosoma beetle,[6] two species of parasitic flies,[7] one of which attacks the brown-tail moth as well as caterpillars of many native insects, and two species of small wasplike flies,[8] one of which attacks the brown-tail moth. Two tiny parasites of the gipsy-moth eggs have also been introduced and colonized, one[9] from Japan and the other[10] from Europe.

Several other parasites have been introduced and are established in this country, but have not increased sufficiently to be considered important factors in gipsy-moth control.

The work of the natural enemies of the gipsy moth, including the imported parasites, the Calosoma beetle, and the wilt disease, has greatly reduced the numbers of the insect in many localities that are badly infested.

It is hoped that when the enemies of the moth are present in larger numbers over the entire infested territory the insect will become much less destructive than at present.

Colonization of some of the species has been carried on throughout the entire area, but much remains to be done with others, particularly the egg parasites. The records at the Gipsy Moth Laboratory at Melrose Highlands, Mass., indicate that all of the species of parasites mentioned have increased gradually in the field during the last few years, and the results of their work are noticeable in certain areas. Until the natural enemies become more abundant than they are at present throughout the entire infested area it will be necessary to employ the most effective mechanical methods for restricting the spread and curtailing the increase of this species. In the meantime further work is being done in foreign lands, particularly in Japan and Germany, to determine the principal factors that are responsible for the periodical scarcity of the insect there and to take advantage of this knowledge for the purpose of developing more effective natural control in this country.

THE BROWN-TAIL MOTH.

LIFE HISTORY.

The stages of the brown-tail moth are shown in Figure 6.

The eggs.—The female brown-tail moth deposits a small cluster of eggs on the under side of a leaf. These eggs are usually laid in July

---

[6] *Calosoma sycophanta* L.
[7] *Blepharipa scutellata* Desv. and *Compsilura concinnata* Meig.
[8] *Apanteles melanoscelus* Ratz. and *A. lacteicolor* Vier.
[9] *Schedius kuvanae* How.
[10] *Anastatus bifasciatus* Fonsc.

and are covered with brown hair taken from the body of the female. Hatching begins about the 15th of August.

The larvæ.—The newly hatched larvæ of this insect feed on the epidermis of the leaf and after molting once or twice begin to con-

FIG. 6.—Different stages of the brown-tail moth: Winter nest at upper left; male and female adults, lower right; cocoon in leaves, upper right; male and female chrysalids above, male at left; full-grown larva in center, somewhat reduced; young larvæ at its left; egg mass removed from leaf, showing single eggs, at lower left; female ovipositing on leaf; egg mass also on same leaf.

struct a winter web. This is made by drawing together several terminal leaves and securely fastening them by silk which is secreted by the caterpillars. The larvæ from one or more egg clusters live and feed in common, and as cold weather approaches they retire to the

web, in which they remain during the winter. In the spring these larvæ leave the web as soon as the buds begin to develop and feed upon the bud scales and small leaflets. They become full grown about the middle of June.

The pupæ.—After the caterpillars finish feeding they spin loose silken cocoons and pupate within them. These cocoons are sometimes constructed separately, but in many cases large numbers of them are spun in a single mass. About two weeks are spent as pupæ.

The adults.—Emergence of the moth usually begins the first week in July. The adult brown-tail moth is pure white. The abdomen of the female is much larger than that of the male, but in both sexes the tip of the abdomen is covered with dark-brown hairs. These moths are attracted to strong light, such as electric arc lights; and as they fly at night, it is often possible to secure many specimens around the arc lights in cities and towns during the first half of July.

FOOD PLANTS.

The caterpillars of the brown-tail moth commonly feed on the leaves of apple, pear, plum, oak, and willow, and they are sometimes found in considerable numbers on elm, maple, and rose and in smaller numbers on other common deciduous trees and shrubs. They never attack conifers and are seldom found on hickory, ash, chestnut, or birch.

INJURY CAUSED BY THE BROWN-TAIL MOTH.

The principal injury caused by the brown-tail moth is due to the feeding of the larvæ in the spring. If the infestation is bad the caterpillars are often numerous enough to devour the leaves as fast as the trees are able to develop them. As the webs are made on the terminals, the growth of the trees is often severely checked. In severe infestations trees may be completely stripped (Fig. 7), but as the larvæ become full grown during the first part of June, there is usually an opportunity for the trees to refoliate before midsummer. The young larvæ that hatch in August frequently skeletonize the leaves to a considerable extent. This does not damage the trees seriously, as the growing period for the season is nearly completed.

The bodies of the caterpillars of the brown-tail moth are provided with poisonous hairs. A microscopic examination of these hairs shows that the edges are barbed in such a way that when they come in contact with the human skin and are pressed into the flesh, intense irritation is caused. These hairs are also hollow and contain a poisonous substance which acts on the blood corpuscles. This causes serious poisoning and severe irritation, accompanied with external swelling, which is known as the brown-tail rash. Persons differ considerably in their susceptibility to this poison, but many cases are reported each year in the infested region, most of which are more serious than those of ivy poisoning. Many camps and summer cottages, particularly in wooded areas, can not be occupied with any comfort during the early summer if the caterpillars are abundant, on account of the poisoning due to these caterpillars. If clothing is hung on the line near badly infested trees the hairs frequently find

lodgment and are brought into the houses, and severe poisoning may result later.

The brown-tail moth has been less abundant during the last three years than heretofore. There have been local infestations, however, where serious injury resulted.

NATIVE ENEMIES.

One of the important native enemies of the brown-tail moth is a fungus disease[11] which attacks the caterpillars, particularly in the spring. It was first reported in this country by Dr. Roland Thaxter in 1888. Like all diseases of this nature, the benefit derived from it is regulated largely by favorable or unfavorable weather conditions. This fungus sometimes works to a slight degree on the small caterpillars in the fall, and in some instances it is found in the winter

FIG. 7.—Apple trees stripped by brown-tail moth caterpillars. Note old winter webs at tops of trees.

webs. As a rule, however, the greatest mortality of caterpillars takes place in the spring, when they are nearly full grown, and the pupæ may, under the most favorable conditions, be almost completely exterminated.

Native parasites and predacious insects have done very little to check the increase of the brown-tail moth.

INTRODUCED PARASITES AND ENEMIES.

Some of the parasites[12] that were introduced as enemies of the gipsy moth caterpillars attack the brown-tail moth freely, and one additional introduced species[13] is an important enemy of the latter

[11] *Entomophthora aulicae.*
[12] *Apanteles lacteicolor* Vier. and *Compsilura concinnata* Meig.
[13] *Meteorus versicolor* Wesm.

insect. The Calosoma beetle,[14] both in the adult and in the larva stage, destroys many brown-tail moth larvæ and pupæ.

The parasites and natural enemies of this insect are more effective than is the case with the gipsy moth, and extremely low temperature in the winter often proves fatal to a large proportion of the small caterpillars in the webs.

These factors, together with an enormous amount of hand suppression that has been employed in many parts of the infested area, have resulted in a pronounced decrease in the abundance of the insect during the last few years.

METHODS OF CONTROLLING THE GIPSY MOTH.

GENERAL METHODS.

Creosote.—One of the best methods of controlling the gipsy moth is to treat the egg clusters of the insect between August 1 and April 1 with creosote, to which a small amount of lampblack has been added. The material is sold by dealers in the infested region under the name of gipsy-moth creosote. It is applied with a brush and leaves a black residue on the clusters treated. Creosote may be obtained from nearly all the large hardware or seed stores in the infested district.

Burlap bands.—Gipsy-moth caterpillars usually seek shelter during hot, sunny days, and if a band of burlap is attached to a tree (Fig. 8), large numbers of them will crawl beneath it, where they may be crushed each day. Ordinarily a strip of burlap about 8 inches wide is placed loosely around a tree trunk and a piece of twine passed around the center and tied to hold it in place. After this is done the top part of the burlap is folded down so that a double shelter is made beneath it. The use of burlap bands has been discontinued during the last few years, owing to the expense involved and because of the fact that if the burlaps are applied early in the season, before the brown-tail moth caterpillars have pupated, an excellent place is furnished for these poisonous caterpillars to make their cocoons, and severe poisoning results to the workmen. If this method is to be used at all, the burlap should not be attached to the trees until after June 15, when most of the brown-tail moth caterpillars will have pupated.

Sticky bands.—Bands of a widely known sticky substance for use in banding trees, which may be obtained on the market, may be used on tree trunks after the bark has been scraped so that the material can be applied evenly in a thin layer with a paddle. The purpose of this band is to prevent caterpillars from ascending the trees, and if previously the egg clusters have been treated, this is a very effective measure. It is necessary every week or 10 days during the caterpillar season to run a comb or other similar implement over the band in order to prevent hardening of the surface and to bring up fresh, sticky material from the part of the band near the bark. (See Fig. 9.) Placing these bands on the trees prevents the caterpillars from reaching the foliage; and as they usually mass in

[14] *Calosoma sycophanta* L.

large numbers beneath the bands, conditions are favorable for wilt disease to develop, and the caterpillars often die in large numbers from this cause and from starvation.

Gipsy moth tree-banding material.[15]—This is a black greasy substance which was prepared and tested by the Bureau of Entomology in cooperation with the Bureau of Chemistry. It is similar to the product known as "raupenleim" that has been used in the German forests for many years to prevent injury to the trees by caterpillars. It is applied with a special "gun" designed for the purpose. (Fig. 10.) A thick, narrow, band is left on the tree trunk, preventing the

FIG. 8.—Burlap band on tree. The caterpillars beneath it are nearly all those of the brown-tail moth.

caterpillars from reaching the foliage. This material is cheap and effective and is easily applied because it is not necessary to scrape the trees before it is put on.

Spraying.—The most effective spray material for the gipsy moth is arsenate of lead. It can be used either in the paste or in the powder form. If paste is used, from 10 to 12 pounds is required for each 100 gallons of water. If powder is used, one-half the amount is sufficient for the same quantity of water.

[15] For full information concerning its preparation and use consult Department Bulletin 899, U. S. Department of Agriculture.

For small operations the ordinary orchard sprayer may be used with one or more lines of hose, depending on the pressure that is available. Nozzles of the Vermorel or Bordeaux type are satisfactory.

FIG. 9.—Sticky band. Note that there are enormous numbers of gipsy-moth caterpillars below the band, but none above it.

In case large shade trees or valuable park or woodland trees are to be treated, the use of a high-power sprayer is more economical. The type that has given the most satisfactory results in the gipsy-moth work develops sufficient power to throw a solid stream of spray so

that it will drift through the trees. (Fig. 11.) The nozzle is constructed so that the stream will break into a fine mist high in the air, and this results in very satisfactory and rapid work. With such a sprayer it is unnecessary to use small hose and climb trees, which is a slow and expensive operation.

A satisfactory high-power sprayer for this work is equipped with not less than a 10-horsepower gasoline engine and a triplex pump

FIG. 10.—Applying tree-banding material to protect the foliage from gipsy-moth caterpillars.

capable of delivering at least 35 gallons of liquid per minute at a pressure of from 225 to 350 pounds. This machinery, together with a 400-gallon tank, should be mounted on a well-built truck. One-inch hose is used, and by slightly increasing the pressure at the machine the spray material can be conducted through several hundred feet of this hose with the outfit mentioned without seriously reducing the nozzle pressure, which should be maintained at about 225 pounds.

In cases where 1,000 feet or more of hose is to be used the pressure must be increased, and when approximately a mile of hose is required in rough country it is frequently necessary to maintain a working pressure of 1,000 pounds. For such heavy work $1\frac{1}{8}$-inch hose gives

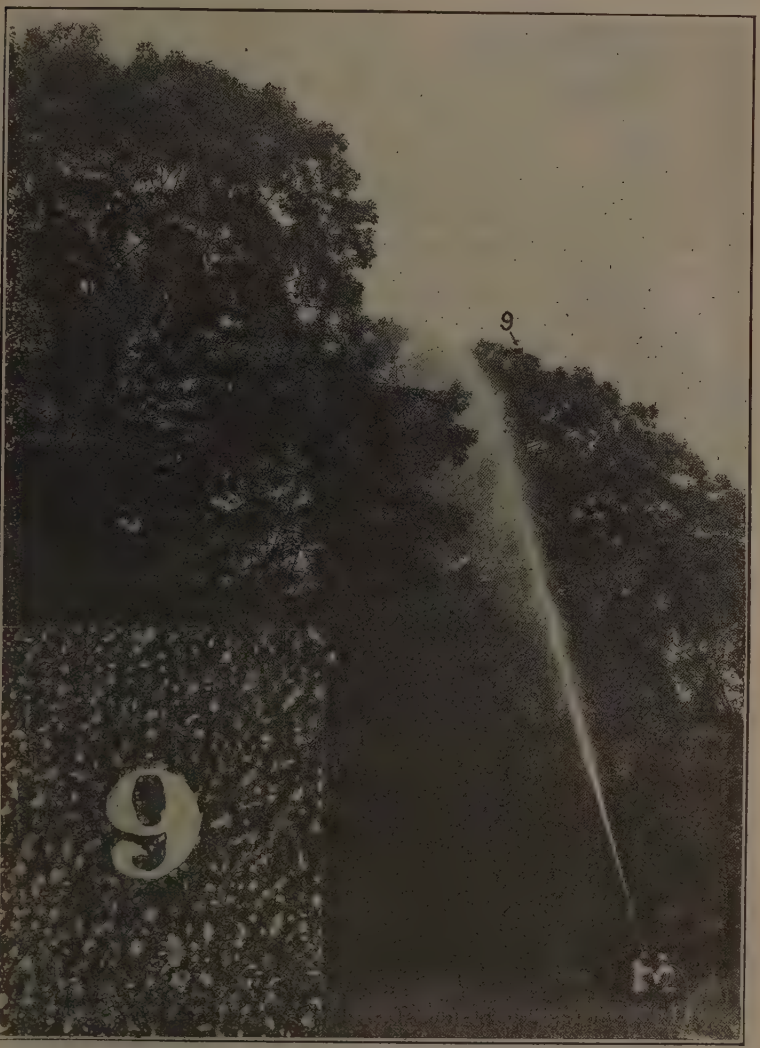


FIG. 11.—Spraying trees 85 feet high with high-power sprayer. Note thorough distribution of poison on plate (9) located at top of tree. (Worthley.)

more satisfactory results than smaller hose, as the friction is considerably less. Pumps of heavier design are necessary, and it is advisable to mount them on motor trucks to make the outfit more mobile. (Fig. 12.)

By using a small device, which is attached to the nozzle and is known as a spreader, it is possible to spray low growth very satisfactorily. Fruit trees can be treated very rapidly in this way. (Fig. 13.)

METHODS TO BE USED IN ORCHARDS.

The methods to be used for controlling the gipsy moth in orchards depend largely on the severity of the infestation. If only a few egg clusters are present in the orchard, the early spraying which is applied for the codling moth after the blossoms fall will be found useful, providing the amount of arsenate of lead used is increased to 10 pounds of paste, or 5 pounds of powder, to 100 gallons of water. If the infestation is more serious, a second spraying early in June, using

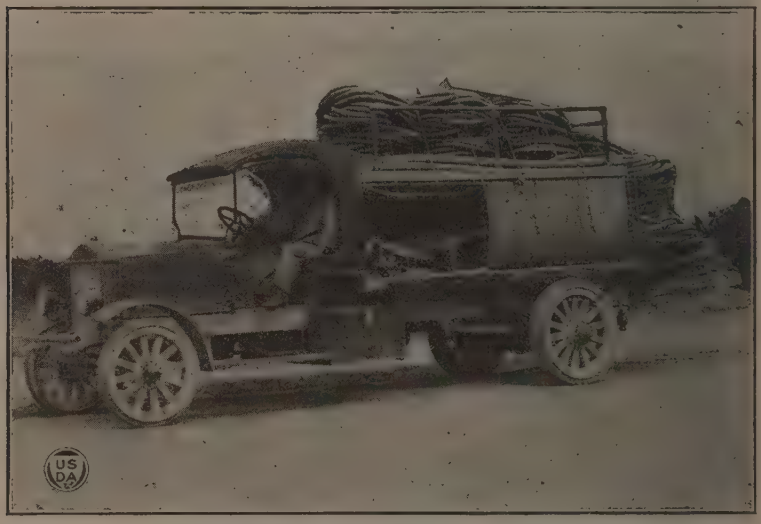


FIG. 12.—Heavy motor-truck sprayer fully equipped.

a similar amount of poison, will be found very satisfactory. Where the infestation is severe, it will probably be necessary to creosote egg clusters in the winter and spray in the spring. Thoroughness is a prime essential if good results are to be obtained.

All poor or hollow trees should be removed; and if badly infested woodland is near by, the orchard trees should be banded. Orchard infestations can be managed by following these methods, and it will not require much additional expense or a great deal of extra work to protect the trees. In making this statement it is assumed that the orchard is being cared for by up-to-date methods to protect it from the codling moth and other injurious insects and diseases, and it is improbable that these results can be brought about in neglected orchards or where the owners do not practice the best horticultural methods in handling their growing trees.

METHODS ADVISABLE IN CITIES AND TOWNS.

The same methods that are used in orchards are applicable in cities and towns and for the treatment of park and shade trees. In certain instances it would probably be advisable to use tree-banding material or burlap, preferably the former, and to discontinue spraying in cases where the infestation is light or moderate. If the infestation is bad, creosoting, banding, and spraying should all be used in their season, in order to bring the insect under control and reduce the numbers present to a minimum.

The method of handling the gipsy moth in any town, city, or park, or on private estates, should be based on the infestation as determined by some one who is familiar with gipsy-moth work, if the best results are to be secured at a minimum expense. Much energy and money may be wasted in applying remedies unless their application is based on a thorough knowledge of existing conditions. An owner of an infested estate should have an examination made by some qualified person who can give reliable recommendations as to

FIG. 13.—Spraying orchard with solid stream, using spreader. (Worthley.)

treatment. It should be borne in mind that conditions as to infestation vary from year to year, and this should be considered when plans for treatment are being made.

CONTROLLING THE GIPSY MOTH IN WOODLAND.

Satisfactory control of the gipsy moth in woodland by the employment of hand methods such as have already been mentioned is impracticable under present conditions, unless the tree growth is particularly valued for purposes other than lumber. If the woodland is situated near a large city and occupies space that is likely to be utilized in a few years for building lots, considerable money may be expended to advantage in protecting the trees, as these will make the property much more valuable when the land is subdivided. Limited areas of woodland on private estates may be of sufficient value to the owners to justify a considerable expenditure for moth destruction. In all cases, however, the species of trees involved should be carefully studied before a plan of work is adopted, in order

that the expense may be reduced as much as possible. Unfortunately the difficulty of treating the woodlands in the infested area of New England is considerably increased by the fact that they are for the most part composed of a variety of species in mixture.

Experiments have shown that most coniferous trees are not injured by the gipsy moth if grown in isolated pure stands; and if the growth is such that the trees can be thinned to a stand of immune species, no hand suppressive measures are necessary in order to prevent injury by this insect. Such lots will not be attacked by the brown-tail moth, as the larvæ of this insect do not feed on conifers.

If mixtures containing a large percentage of deciduous trees are to be protected from moth injury, it is very necessary that the species involved should be carefully considered before a decision is reached as to the best methods of treatment. Sometimes practical methods

FIG. 14.—Mixed deciduous and coniferous woodland before thinning.

of thinning (Figs. 14, 15) can be adopted so that species will be left that are only slightly subject to injury by these insects. A limited number of experiments have shown that mixtures of chestnut, pine, red maple, ash, and hickory, regardless of the proportion of each species, are seldom injured by the gipsy moth.

In woodlands the oaks are the most favored food plant of this insect, and, unfortunately, the infested region abounds in large areas where these species predominate. At present there seems to be no means aside from hand treatment which will prevent serious injury to oak woodland, but, as a large part of such land consists of poor sprout growth, the amount of damage sustained is not always so great as it might at first appear. The greatest injury likely to be caused in such areas where oaks and gray birch abound is the dying of small seedlings of pine or other valuable species which have been denuded by

the caterpillars after the oaks and birches have been defoliated. This leaves the prospective woodland in a much worse condition than it was before the defoliation took place and reduces greatly the chance that the sprout growth will be replaced by any species of value that can withstand gipsy-moth attack. Special study and consideration is being given to devising some economical method for protecting and improving wood lots of this character at moderate expense. It is true that in considerable areas of oak woodland the trees, although not mature, could be utilized for small timber, railroad ties, or cordwood, and in cases of bad infestation such woodland should be promptly cut if the wood can be sold to advantage. On cheap cut-over or infested lands in many sections of the territory white pine might be planted to advantage, but as this involves considerable expense and as the future crop can not be harvested for a period of years,

FIG. 15.—Same woodland after growth favored by the gipsy moth has been removed by thinning.

the question as to the desirability of managing any wood lot in this way must in the end be decided by the owner of the property.

If the practice common in some European countries of maintaining municipal or State forests were well developed in the New England States, it would be possible in a period of years to transform considerable areas of land which are now destined to be worthless, and which form a favorable feeding ground for the gipsy moth, into well-managed forests of valuable growth.

METHODS OF CONTROLLING THE BROWN-TAIL MOTH.

The brown-tail moth can be controlled by cutting off the winter webs and burning them before the caterpillars begin to emerge in April. *These webs should be destroyed by fire*, for if they are simply cut from the tree and left on the ground the caterpillars

will emerge and no benefit will result from the work which has been done.

In orchard practice it is sometimes inadvisable to cut the winter webs, for where an infestation is bad it is likely to leave a poorly shaped tree. Spraying in the spring is not a satisfactory remedy unless the infestation is very light, because the caterpillars, when they occur in large numbers, do not allow the tree to put out sufficient foliage to hold the spray material.

The most effective method in orchards is to spray the trees before the middle of August, using from 3 to 5 pounds of arsenate of lead powder to 100 gallons of water. Before spraying operations of this sort are attempted determine to what extent the trees are infested with egg masses of the brown-tail moth. If the infestation is very slight, it will be more satisfactory to cut and destroy the webs. If the infestation warrants, both shade, ornamental, and fruit trees may be sprayed to advantage at this time. Caution should be used, however, in spraying fruit trees, particularly if early fall varieties are to be treated. If this is to be done, a somewhat weaker spray solution may be used, provided it is applied as soon as the caterpillars begin to hatch. The foliage should be treated thoroughly, particularly the terminal shoots, and as much care as possible should be exercised not to cover the fruit. Late fall or winter varieties of fruit may be sprayed in August with arsenate of lead, using 3 pounds powder to 100 gallons of water, and although an occasional spot may be found on the fruit at the time of picking no injury will result from it. In cases where only a few choice fruit trees are sprayed it is practicable to wipe the fruit before packing for sale; but this will not be necessary if care is taken to spray only the terminal growth of the trees, as this is where the bulk of the egg clusters are deposited.

CONTROLLING THE BROWN-TAIL MOTH IN WOODLAND.

The damage caused by the brown-tail moth is ordinarily not so severe as that resulting from gipsy-moth infestation, because the former species does not have so wide a range of food plants and, further, because the bulk of the feeding by the larvæ of the brown-tail moth is done early in the season, so that the trees have an opportunity to recover before midsummer. In the territory where both insects exist the caterpillars of the gipsy moth supplement the work which is done by those of the brown-tail moth, and the injury is, therefore, greatly increased.

During the last few years this insect has seldom been found feeding on oak foliage, except in the worst-infested localities, and elm trees are not as badly infested as was the case about 10 years ago.

Thorough destruction of brown-tail moth webs in residential sections and in orchards has resulted in materially decreasing the insect in thickly settled sections. Elimination of worthless apple and wild cherry trees would help greatly in reducing the pest.

ORGANIZATION AND STATUS OF WORK AGAINST THE GIPSY MOTH AND THE BROWN-TAIL MOTH.

STATE WORK.

Each of the New England States is carrying on work for the control of the gipsy moth and the brown-tail moth. The organization varies because of local conditions, but the same general methods of field work are employed.

In Maine the work is in charge of the commissioner of agriculture, who has authority to appoint a superintendent of moth work. The southwestern portion of the State is from generally to badly infested with the gipsy moth, while in the outlying area only scattering infestations have been found. The brown-tail moth is not now seriously abundant, but is found most commonly along the coast and near the main watercourses. Ten thousand square miles of territory in Maine are infested with the gipsy moth and about 7,000 with the brown-tail moth. The former has gradually spread to new territory, but the area infested by the latter has decreased sharply during the last five years.

In New Hampshire the moth work is in charge of the State entomologist. Over 7,000 square miles of territory are infested with the gipsy moth and about 3,600 with the brown-tail moth. The heaviest gipsy-moth infestations in the State are south of the latitude of Lake Winnepesaukee.

In Vermont the moth work is in charge of the commissioner of agriculture, who appoints a deputy to carry on the field work. During the last three years the territory infested with the gipsy moth has increased rapidly and over 2,000 square miles are now known to be infested. The brown-tail moth has not been found in the State during the last two years except a few webs discovered during the winter of 1922–23 in two towns bordering the Connecticut River.

The commissioner of conservation has charge of the moth work in Massachusetts. Each infested town is required by law to select a local superintendent, whose appointment must be approved by the commissioner. Owners are required by law to keep their property free from these pests, but can not be compelled to expend for this purpose more than $5 on each $1,000 assessed valuation. Towns and cities must expend funds for proper treatment of the street trees and those in parks and on public grounds. After the amounts fixed by law are expended, financial aid is supplied by the State. The gipsy moth at present occurs to a greater or less extent in nearly every town in the State, but most of the territory west of the Connecticut River is lightly infested. The area infested by the brown-tail moth has been reduced so that at present it amounts to only a little over 4,000 square miles.

In Rhode Island the State board of agriculture has charge of the moth work, which is done under the supervision of the State entomologist. The gipsy moth occurs in all towns in the State, but is most abundant in the northern part. The brown-tail moth infestation has decreased rapidly in the last few years and at present none of the towns are known to be infested.

In Connecticut the work is in charge of the State entomologist. The brown-tail moth has not been found in this State for several

years. The gipsy-moth area has increased rapidly during the last three years, and nearly 2,000 square miles are now known to be infested. The food plants in this State are favorable to the rapid increase of the insect, but, although scattering infestations have been found over a much larger area than heretofore, thorough treatment has prevented injury to trees from this insect up to the present time.

In New York State the field work against the small number of scattered infestations that have been found has been supervised by the director of the Bureau of Plant Industry of the Department of Farms and Markets.[16] Close cooperative arrangements have existed between that office and the Bureau of Entomology of the United States Department of Agriculture, and both organizations have expended funds in defraying the expenses of the control work.

In New Jersey the State work is under the control of the department of agriculture. The funds appropriated have been used in conjunction with Federal funds and the direct supervision of the work has been in the hands of the United States Bureau of Entomology. The results up to the present time have been very satisfactory.

Work on one small colony in Pennsylvania and another in Ohio was done by arrangement with the State officials—in Pennsylvania with the bureau of plant industry of the department of agriculture of that State and in Ohio with the State nursery inspector. The results were satisfactory, as both colonies of the insects have been exterminated.

WORK OF THE BUREAU OF ENTOMOLOGY.

The work of the Bureau of Entomology of the United States Department of Agriculture against the gipsy moth and the brown-tail moth is designed to prevent the spread of these insects. For a number of years it was believed to be quite impossible to restrict the spread of the brown-tail moth on account of the heavy migration of the adults of this species. In recent years, owing principally to the effectiveness of parasites introduced by the bureau, winter conditions unfavorable to the insect, and in some sections the effectiveness of a fungous disease which attacks the caterpillars, in addition to a large amount of hand-suppression work, it has been possible not only to prevent spread but to record a marked reduction in the infested area. In certain sections near the seacoast in northern Massachusetts and New Hampshire and near some of the rivers, however, rather heavy infestations exist. One of the dangers in connection with the brown-tail moth at present is that favorable climatic conditions or temporary scarcity of natural enemies may enable it to increase rapidly and spread proportionately.

The gipsy moth was held in check for several years and did not spread beyond the Connecticut River. During the war period, when extreme difficulty was experienced in maintaining a field force on an effective basis, infestations developed rapidly, and as the result of favorable winds immediately following the hatching period, extensive spread of the insect to the west and northwest resulted.

Recent field work indicates that many colonies were established during that period, and scattered infestations have been found in

[16] In March, 1923, the gipsy-moth work was transferred to the Department of Conservation.

the Berkshire Hills section of Massachusetts and Connecticut and in the Green Mountain Range in Vermont. This territory is extremely rugged and very difficult for field operations.

A project is under consideration at present of selecting a zone west of this area but east of the Hudson River, where the territory is more favorable for field operations, with the purpose of operating therein and preventing further westward spread.

In town or city work the Bureau of Entomology advises that careful attention be given to woodland infestation or isolated trees, particularly if they are located on high elevations immediately outside the residential area, as colonies in such locations may furnish a supply of caterpillars which will be distributed throughout the town after it has been cleaned. Under present conditions, owing to the decrease in the severity of gipsy-moth infestation in many sections, spraying becomes an economic means of treatment and in some cases is used exclusively for control.

A large amount of experimental work has been done to devise better methods of controlling these insects. Natural enemies have been introduced from Europe and Japan and colonized throughout most of the infested area. Specialists have spent considerable time studying these insects in their native homes and collecting parasites for shipment to this country. This phase of the work is being pressed as rapidly as possible. Investigations looking toward the planting and growing of forest trees that are not subject to attack by this insect are being continued.

The entire area known to be infested by either of these insects is under quarantine by the Federal Horticultural Board, and shipments of nursery stock, lumber, cordwood, and other forest products, and stone and quarry products, are not permitted to leave the territory unless they are inspected and accompanied by a certificate stating that they are free from infestation.

COOPERATIVE WORK.

Since the gipsy moth and brown-tail moth work was begun by the Bureau of Entomology more or less work has been done in cooperation with the States concerned. The introduction of parasites and natural enemies of the gipsy moth was conducted in cooperation with the State of Massachusetts for several years. After the infestation had covered large areas in other States an arrangement was made for this work to be carried on by the Bureau of Entomology. The general plan of field work in New England is for the bureau to handle the territory embracing several tiers of towns along the outside border of gipsy-moth infestation, while the States manage the work inside this area.

The work in New Jersey is planned with the purpose of exterminating this large infestation, and close cooperation with that State has been maintained.

The New England quarantine covers the entire infested area, while the experimental work, including the introduction and colonization of parasites, is being carried out in a systematic way for the purpose of developing better methods for the use of all concerned to bring about the dispersion of the various parasites over the entire infested area as rapidly as possible.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE.

Secretary of Agriculture	HENRY C. WALLACE.
Assistant Secretary	C. W. PUGSLEY.
Director of Scientific Work	E. D. BALL.
Director of Regulatory Work	
Weather Bureau	CHARLES F. MARVIN, *Chief.*
Bureau of Agricultural Economics	HENRY C. TAYLOR, *Chief.*
Bureau of Animal Industry	JOHN R. MOHLER, *Chief.*
Bureau of Plant Industry	WILLIAM A. TAYLOR, *Chief.*
Forest Service	W. B. GREELEY, *Chief.*
Bureau of Chemistry	WALTER G. CAMPBELL, *Acting Chief.*
Bureau of Soils	MILTON WHITNEY, *Chief.*
Bureau of Entomology	L. O. HOWARD, *Chief.*
Bureau of Biological Survey	E. W. NELSON, *Chief.*
Bureau of Public Roads	THOMAS H. MACDONALD, *Chief.*
Fixed Nitrogen Research Laboratory	F. G. COTTRELL, *Director.*
Division of Accounts and Disbursements	A. ZAPPONE, *Chief.*
Division of Publications	EDWIN C. POWELL, *Acting Chief.*
Library	CLARIBEL R. BARNETT, *Librarian.*
States Relations Service	A. C. TRUE, *Director.*
Federal Horticultural Board	C. L. MARLATT, *Chairman.*
Insecticide and Fungicide Board	J. K. HAYWOOD, *Chairman.*
Packers and Stockyards Administration *Grain Future Trading Act Administration*	CHESTER MORRILL, *Assistant to the Secretary.*
Office of the Solicitor	R. W. WILLIAMS, *Solicitor.*

This bulletin is a contribution from

Bureau of Entomology	L. O. HOWARD, *Chief.*
Gipsy Moth and Brown-Tail Moth Investigations.	A. F. BURGESS, *Entomologist in Charge.*

28

ADDITIONAL COPIES

OF THIS PUBLICATION MAY BE PROCURED FROM
THE SUPERINTENDENT OF DOCUMENTS
GOVERNMENT PRINTING OFFICE
WASHINGTON, D. C.
AT

5 CENTS PER COPY

PURCHASER AGREES NOT TO RESELL OR DISTRIBUTE THIS COPY FOR PROFIT.—PUB. RES. 57, APPROVED MAY 11, 1922

▽